



Designation: D7796 – 21

Standard Test Method for Analysis of Ethyl *tert*-Butyl Ether (ETBE) by Gas Chromatography¹

This standard is issued under the fixed designation D7796; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers the determination of the purity of ethyl *tert*-butyl ether (ETBE) by gas chromatography. It also provides a procedure to measure impurities in ETBE such as C_4 to C_{12} olefins, methyl, isopropyl and *tert*-butyl alcohols, methyl *sec*-butyl and methyl *tert*-amyl ethers, acetone, and methyl ethyl ketone.

1.2 This test method is not applicable to the determination of ETBE in gasoline.

1.3 Water cannot be determined by this test method and shall be measured by a procedure such as Test Method [D6304](#) and the result used to normalize the chromatographic values.

1.4 Most of the impurities in ETBE are resolved by the test method, however, some co-elution is encountered.

1.5 This test method is inappropriate for impurities that boil at temperatures higher than 180 °C or for impurities that cause poor or no response in a flame ionization detector, such as water.

1.6 The values stated in SI units of measurement are preferred and used throughout the standard. Alternate units, in common usage, are also provided to improve clarity and aid the user of this test method.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ This test method is under the jurisdiction of ASTM Committee [D02](#) on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee [D02.04.01](#) on Gas Chromatography Methods.

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2. Referenced Documents

2.1 ASTM Standards:²

[D3700](#) Practice for Obtaining LPG Samples Using a Floating Piston Cylinder

[D4057](#) Practice for Manual Sampling of Petroleum and Petroleum Products

[D4175](#) Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

[D4307](#) Practice for Preparation of Liquid Blends for Use as Analytical Standards

[D4626](#) Practice for Calculation of Gas Chromatographic Response Factors

[D6304](#) Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration

[D7618](#) Specification for Ethyl Tertiary-Butyl Ether (ETBE) for Blending with Aviation Spark-Ignition Engine Fuel

[E355](#) Practice for Gas Chromatography Terms and Relationships

[E594](#) Practice for Testing Flame Ionization Detectors Used in Gas or Supercritical Fluid Chromatography

3. Terminology

3.1 *Definitions*—This test method makes reference to many common and gas chromatographic procedures, terms, and relationships. Detailed definitions of these can be found in Practices [E355](#) and [E594](#), and Terminology [D4175](#).

3.2 Definitions of Terms Specific to This Standard:

3.2.1 C_4 to C_{12} olefins, n —common olefin impurities in ETBE including unreacted feedstock and dimers or trimers of feed such as trimethylpentene or pentamethylheptene.

4. Summary of Test Method

4.1 A representative aliquot of the ETBE product sample is introduced into a gas chromatograph equipped with a methyl silicon bonded phase fused silica open tubular column. Helium carrier gas transports the vaporized aliquot through the column where the components are separated by the chromatographic

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org.

*A Summary of Changes section appears at the end of this standard

process. Components are sensed by a flame ionization detector as they elute from the column.

4.2 The detector signal is processed by an electronic data acquisition system or integrating computer. Each eluting component is identified by comparing its retention time to those established by analyzing standards under identical conditions.

4.3 The concentration of each component in mass percent is determined by normalization of the peak areas after each peak area has been corrected by a detector response multiplication factor and the water content of the sample. The detector response factors are determined by analyzing prepared standards with the concentrations similar to those encountered in the sample.

5. Significance and Use

5.1 The presence of impurities in ETBE product can have a deleterious effect upon the value of ETBE as a fuel additive. Oxygenate and olefin contents are of primary concern. This test method provides a knowledge of the composition of ETBE product. This is useful in the evaluation of process operations control, in the valuation of the product, and for regulatory purposes.

6. Interferences

6.1 Cyclopentane and 2,3-dimethylbutane have been observed to co-elute with MTBE. However, these are not commonly found impurities in MTBE, and MTBE is typically present at very low concentrations in ETBE.

7. Apparatus

7.1 *Gas Chromatograph*—Instrumentation capable of operating at the conditions listed in Table 1. A heated flash vaporizing injector designed to provide a linear sample split injection (that is, 200:1) is required for proper sample introduction. Carrier gas controls shall be of adequate precision to provide reproducible column flows and split ratios in order to maintain analytical integrity. Pressure control devices and gages shall be designed to attain the linear velocity required in the column used (for example, if a 150 m column is used, a

pressure of approximately 550 kPa (80 psig) is required). A hydrogen flame ionization detector with associated gas controls and electronics, designed for optimum response with open tubular columns, is required.

7.2 *Sample Introduction*—Manual or automatic liquid syringe sample injection to the splitting injector is employed. Devices capable of 0.1 μ L to 0.5 μ L injections are suitable. It should be noted that inadequate splitter design, or poor injection technique, or both, can result in poor resolution. Overloading of the column can also cause loss of resolution for some components and, since overloaded peaks are skewed, variation in retention times. Watch for any skewed peaks that indicate overloading during column evaluation. Observe the component size and where possible, avoid conditions leading to this problem during the analyses.

7.3 *Open Tubular Column*³—This test method utilizes a fused silica open tubular column with non-polar methyl silicone bonded (cross-linked) phase internal coating such as one of the following:

Column length	50 m	100 m	150 m
Film thickness	0.5 μ m	0.5 μ m	1.0 μ m
Internal diameter	0.20 mm	0.25 mm	0.25 mm

Other columns with equal or greater resolving power may be used. A minimum resolution between *trans*-2-pentene and *tert*-butanol, and between *cis*-2-pentene and *tert*-butanol of 1.3 is required. The 150 m column is expected to decrease the likelihood of co-elution of impurities.

7.4 *Electronic Data Acquisition System*—Any data acquisition and integration device used for quantification of these analyses shall meet or exceed these minimum requirements:

- 7.4.1 Capacity for at least 50 peaks per analysis,
- 7.4.2 Normalized area percent calculations with response factors,
- 7.4.3 Identification of individual components based on retention time,
- 7.4.4 Noise and spike rejection capability,
- 7.4.5 Sampling rate for fast (<1 s) peaks,
- 7.4.6 Positive and negative sloping baseline correction,
- 7.4.7 Peak detection sensitivity compensation for narrow and broad peaks, and
- 7.4.8 Non-resolved peaks separated by perpendicular drop or tangential skimming as needed.

8. Reagents and Materials

8.1 *Carrier Gas*, helium, 99.99 % pure. (**Warning**—Compressed gas under high pressure.)

8.2 *Fuel Gas*, hydrogen, 99.99 % pure. (**Warning**—Extremely flammable gas under pressure.)

8.3 *Ethyl tert-Butyl Ether*, 99.99 % pure. (**Warning**—Flammable liquid. Harmful if inhaled.)

8.4 *Oxidant*, air, oil free. (**Warning**—Compressed gas under high pressure.)

TABLE 1 Typical Operating Conditions

Column Temperature Program			
Column length	50 m	100 m	150 m
Initial temperature	40 °C	50 °C	60 °C
Initial hold time	13 min	13 min	13 min
Program rate	10 °C/min	10 °C/min	10 °C/min
Final temperature	180 °C	180 °C	180 °C
Final hold time	3 min	7 min	20 min
Injector			
Temperature	200 °C		
Split ratio	200:1		
Sample size	0.1 µL to 0.5 µL		
Detector			
Type	flame ionization		
Temperature	250 °C		
Fuel gas	hydrogen (≈30 mL/min)		
Oxidizing gas	air (≈300 mL/min)		
Make-up gas	nitrogen (≈30 mL/min)		
Carrier Gas			
Type	helium		
Average linear velocity	20 cm/s – 24 cm/s		

³ Petrocol DH series columns from Supelco, Inc., Bellefonte, PA were used to obtain the retention data and example chromatogram shown in this standard. Other suitable columns are available commercially.